Defining & Building a DE Driven Digital Thread

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GLOBAL PRODUCT DATA INTEROPERABILITY SUMMIT 2024

BOEING ELYSIUM NORTHROP GRUMMAN Parker PDES, Inc.® Connecting the Digital Enterprise

Lou Pascarella: CTO Digital Transformation, HCLTech

Louis Pascarella is CTO of HCL's Digital Transformation organization focused on Model Based Engineering & Enterprise Architectures/Solutions, Digital Engineering Product Creation Methodologies/Technologies, Product Lifecycle Management and Digitalization of Enterprise Ecosystems, including Digital Thread/Twins enablement.

He has been working with global Automotive, Aerospace and Software Vendors for over 45 years in the areas of CAD, PLM, Visualization and Software Lifecycle Management with a focus on strategy, planning, consulting, systems engineering, knowledge capture & management.

Mr. Pascarella has a leadership background (CTO, VP R&D, Founder) in PLM/Manufacturing technology development/implementation (Teamcenter, Windchill,& ENOVIA), solution architecture, enterprise middleware technologies, IOT/IIOT.

Currently he is providing thought leadership and strategic advisory guidance supporting HCLTech' s strategic customer's global Digital Transformation initiatives.

Dave Cooper: Digital Transformation Lead, BAE Systems Platforms & Solutions Combat Mission Systems

Dave Cooper is currently the Digital Transformation lead for BAE Systems Platforms & Solutions Combat Mission Systems business unit. He has 35 years of applied engineering and management experience, with the majority focused on strategically-focused system and capability development, advanced design and acquisition technologies, operational mission system capability and effectiveness analysis and simulation, and integrated system development.

Dave joined the BAE Systems in 1997 performing Systems Engineering and weapon system and operational effectiveness analysis and ultimately managed the Modeling & Simulation and System Effectiveness Analysis organization

- Developed and received a patent for BAE Systems' first automated combat vehicle design conceptualization and optimization application
- Led the development of BAE Systems' system and mission simulation, analysis, and Digital Prototype and Twin technology
- Led a BAE Systems US Navy DD21/DDG-1000 Smart Product Model development teams, developing BAE Systems' and the US Navy's first fully accredited synthetic system validation environments
- Chief Engineer for BAE Systems' prime role in the DARPA META program, which was a technology forerunner for Digital Engineering

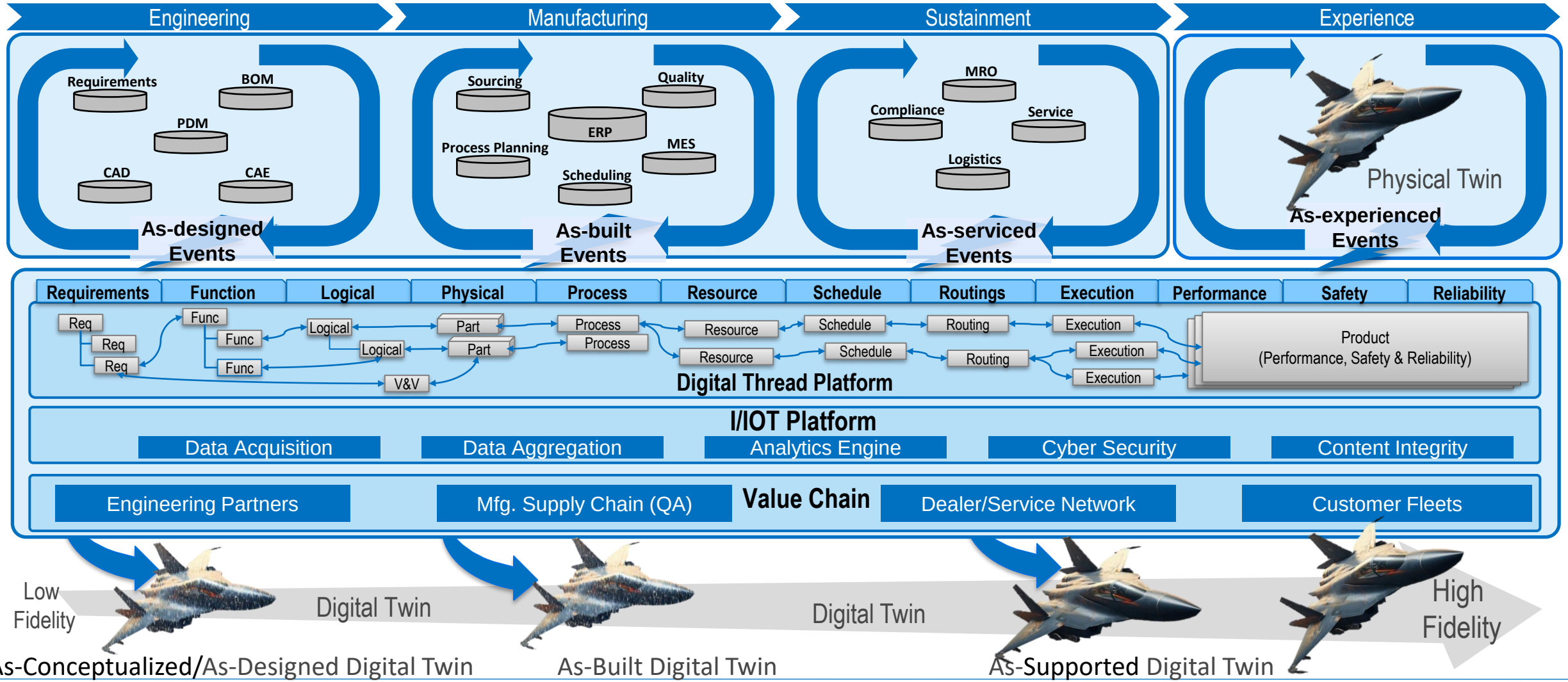
Dave then spent 8 years leading the UK Maritime Indirect Fires program, first as the Engineering Manager and then as the Program Manager for this large and complex international weapon system technology development, production, and commissioning program.

Digital Transformation/Thread/Twin (DT3)

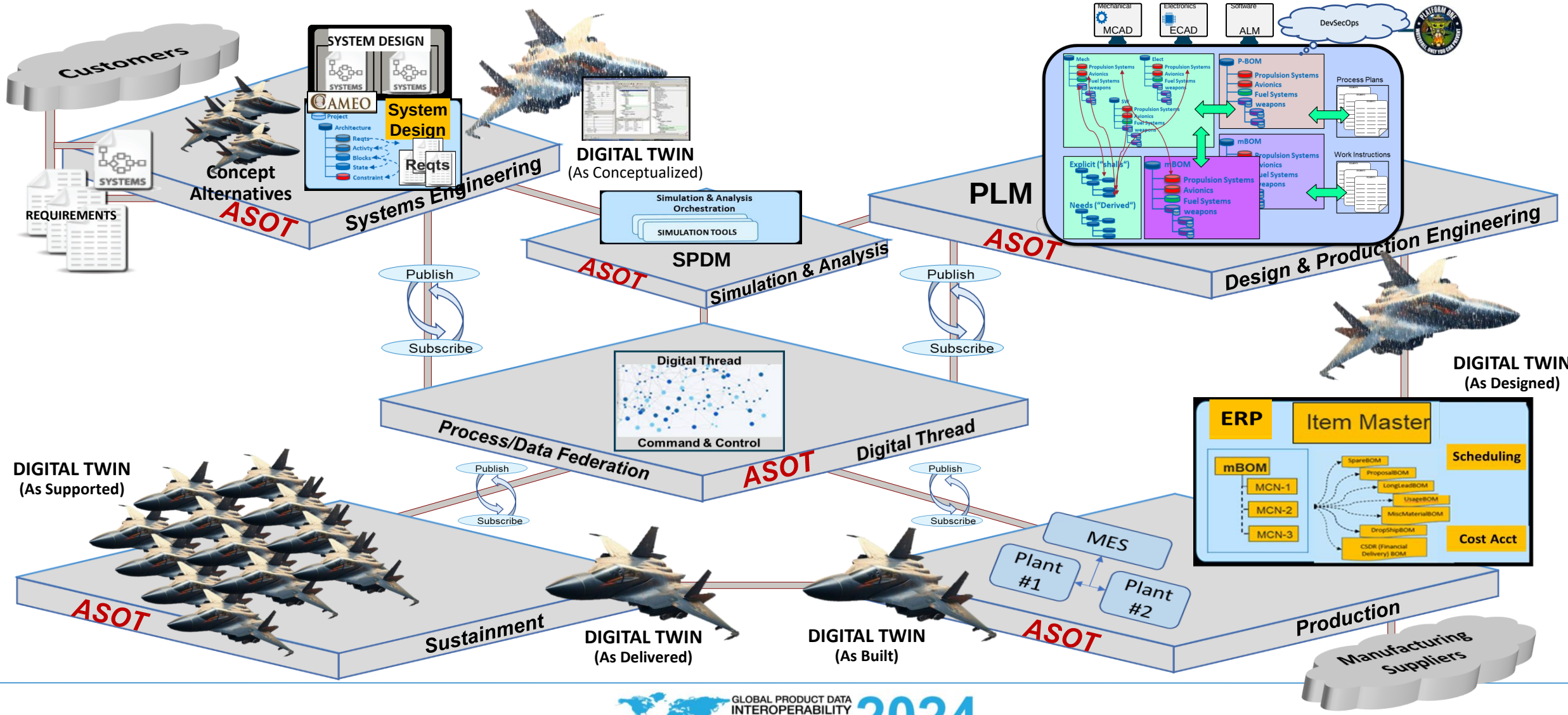
- **Digital Transformation initiatives enhance visibility, traceability, and validation through a highly collaborative product development, production, and sustainment lifecycle**

- **Digital Transformation vision and business objectives highlight the need for advancement of key Model-based Enterprise capabilities that start with a Digital Engineering driven approach**
  - **Clear definition of and Model-Based Engineering paradigm within individual ASoTs**
  - **Multi-directional Model-Based Digital Thread with full associativity of requirements/artifacts across all domain ASoTs**
    - **System Engineering ⇔ Design Engineering ⇔ Manufacturing Engineering ⇔ Production ⇔ Sustainment**
  - **Model-Based Digital Twins defined & initiated at system conceptualization and reflects system maturity with representative Digital Twins at increasing levels of fidelity throughout the system lifecycle**

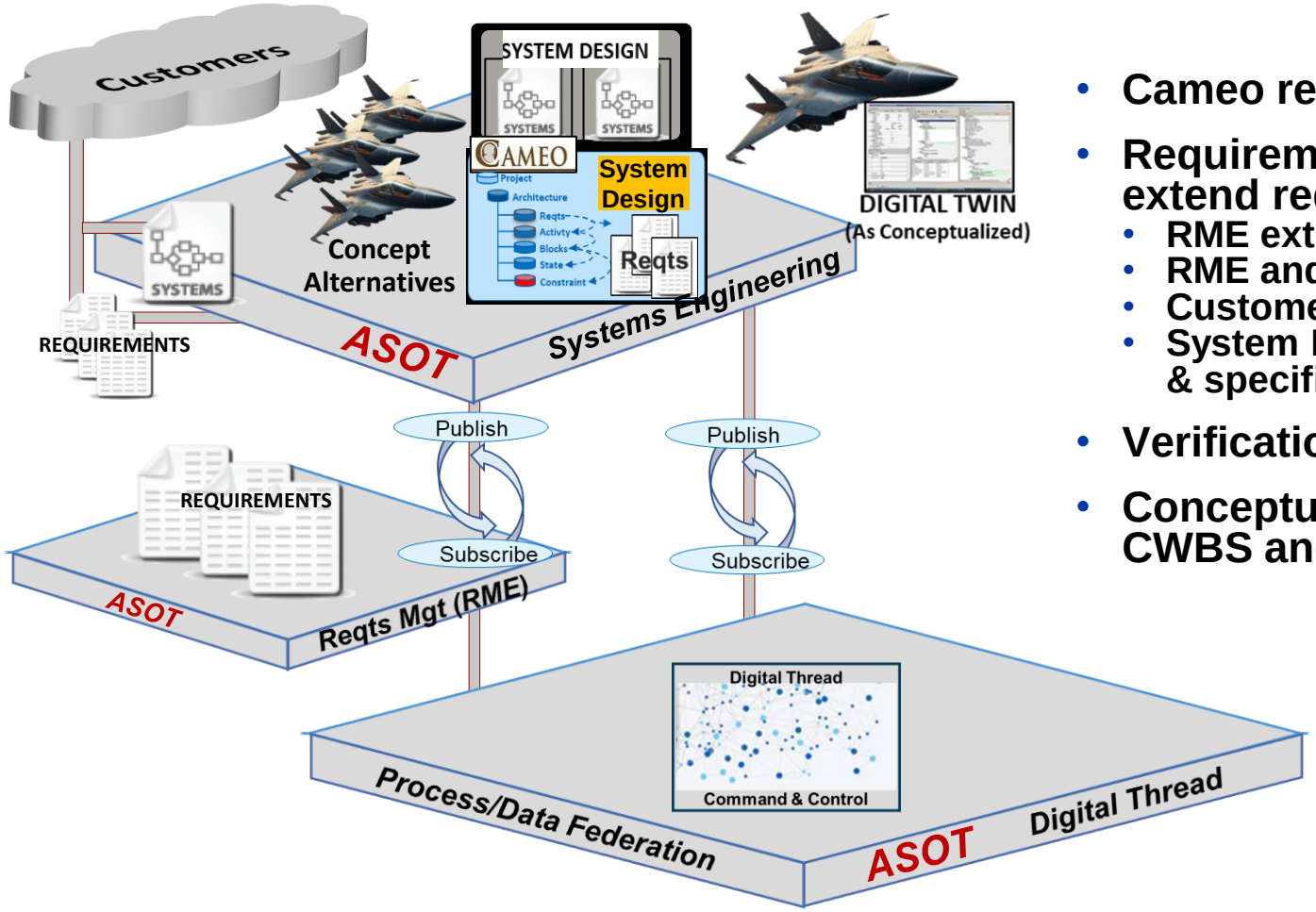
Enabling the Model Based Enterprise → DT/DT Platform



Digital Engineering Solution Topology

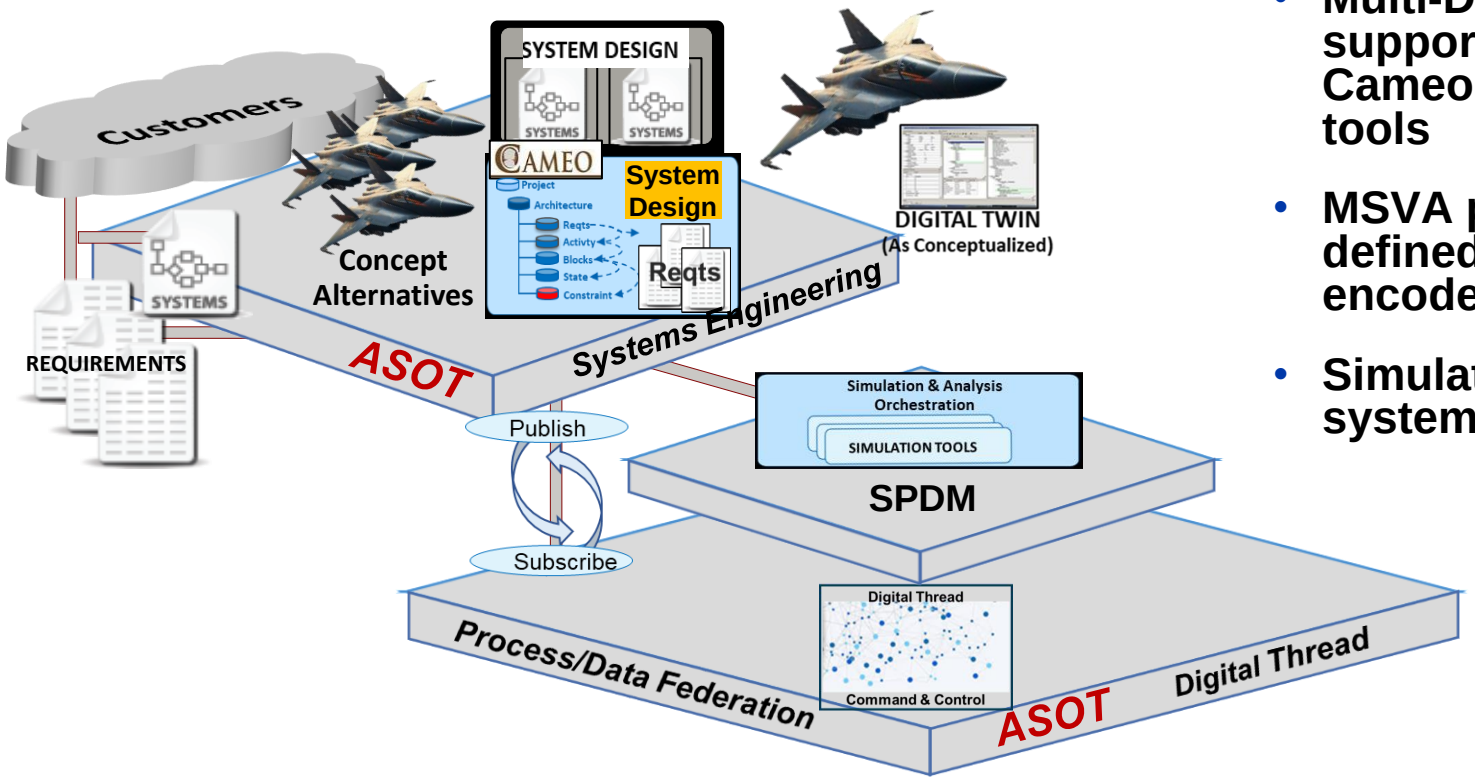


System Design

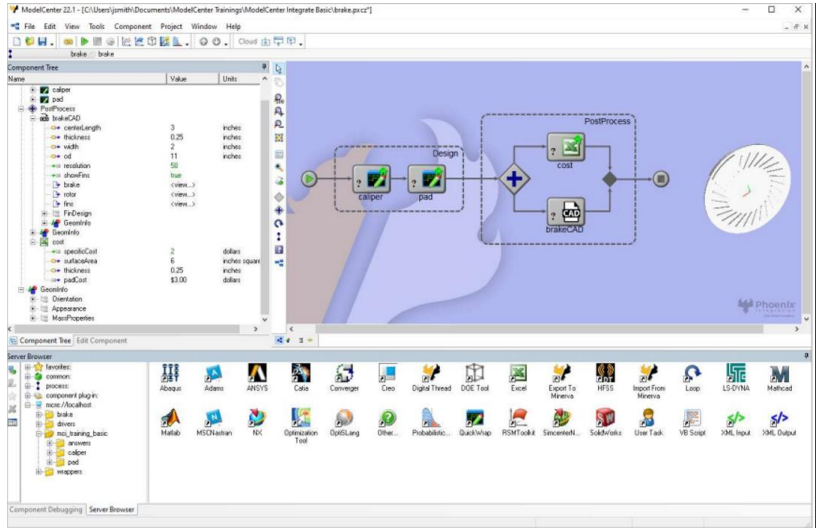


- **Cameo remains standard MBSE environment for DoD**
- **Requirements Management Environment (RME) used to extend requirements management beyond Cameo**
  - **RME extended to capture ALL requirements, not just pSpec**
  - **RME and Cameo linked for bidirectional associativity**
  - **Customer requirements linked to system specifications**
  - **System Design artifacts linked to each other and to requirements & specifications**
- **Verification plans and procedures mechanisms established**
- **Conceptual Product Structure created, associated with CWBS and linked to MBSE artifacts and RME**

System Operational Analysis



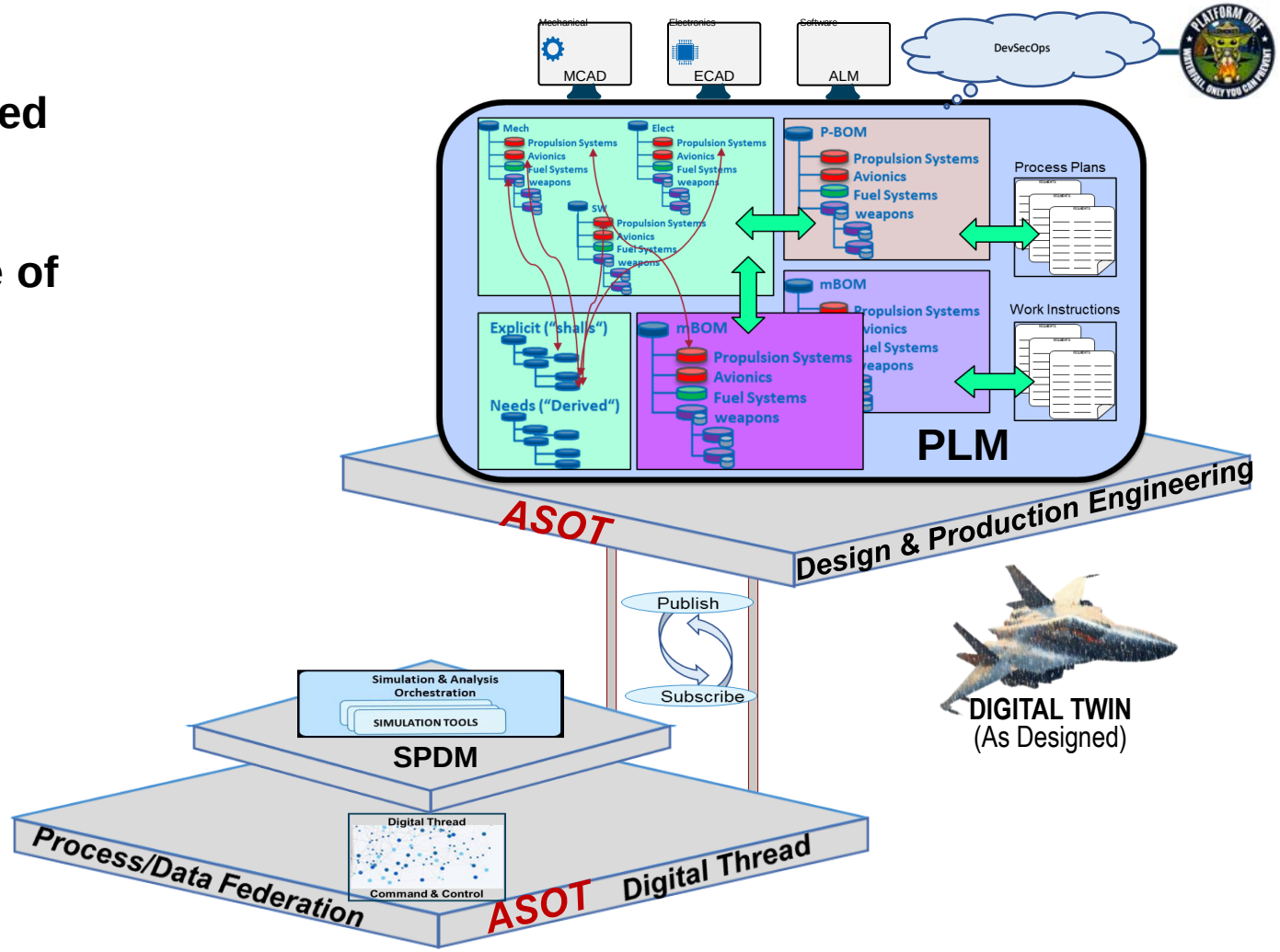
- **Multi-Disciplinary Analysis and Optimization (MDAO) supported through parametric modeling within Cameo and through managed workflows to MSVA tools**
- **MSVA process orchestrator – enables META-like pre-defined analysis and verification workflows to be encoded into processes**
- **Simulation Process and Data Management (SPDM) system for MSVA data and analyses persistence**



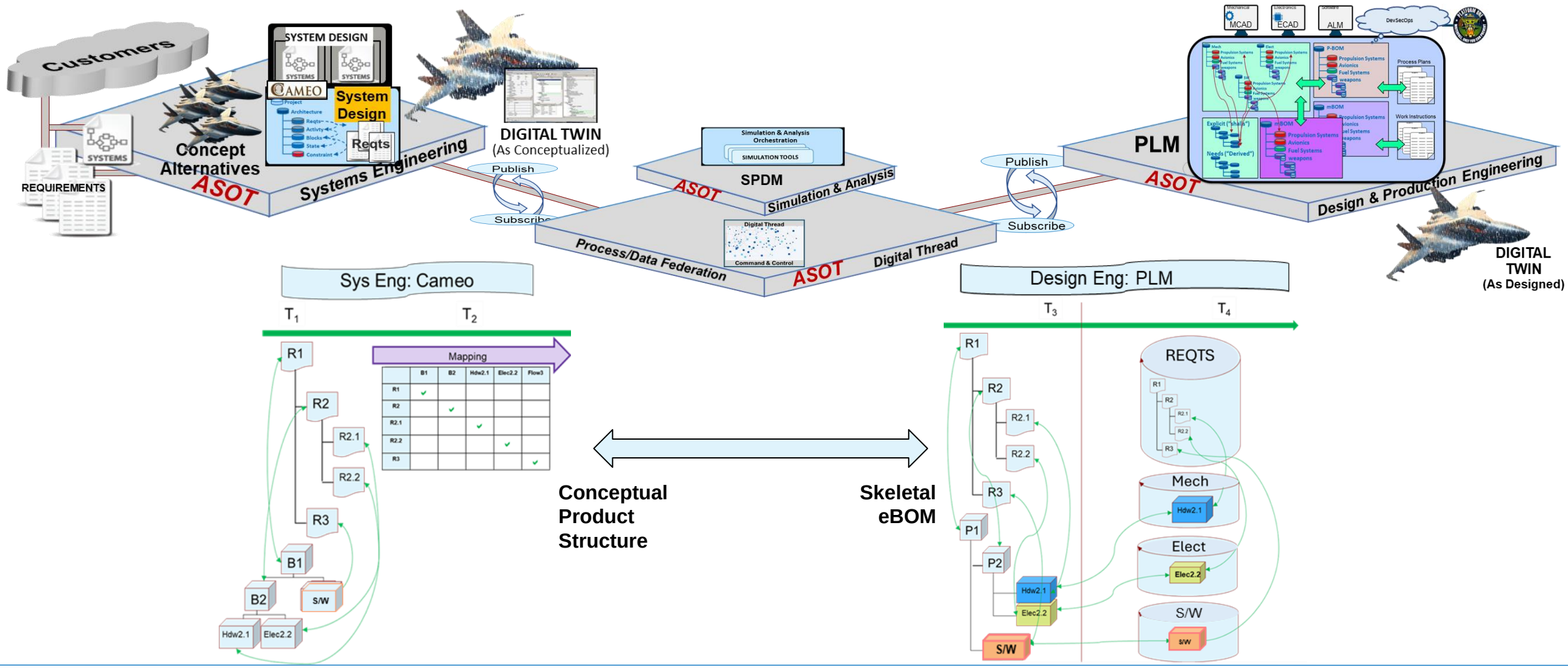
Detail Engineering Analysis

- **High-fidelity simulations managed and persisted through SPDM**
- **Enables comprehensive historical provenance of persisted data & managed analyses**

Automated and managed MSVA workflows enable continuous system validation throughout the development lifecycle

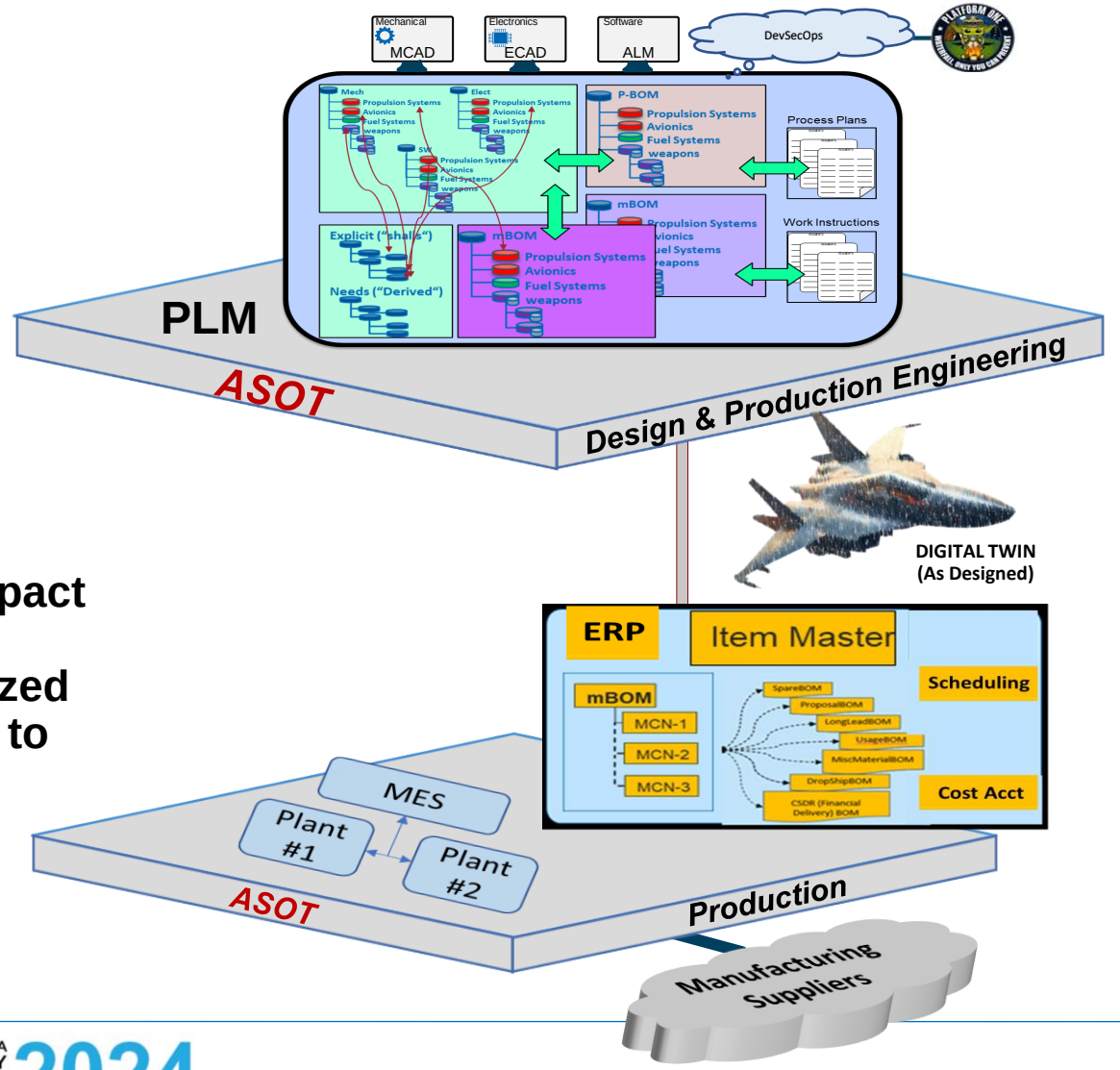


Persistent Mapping between Systems and Design Engineering Environments



Release to Production

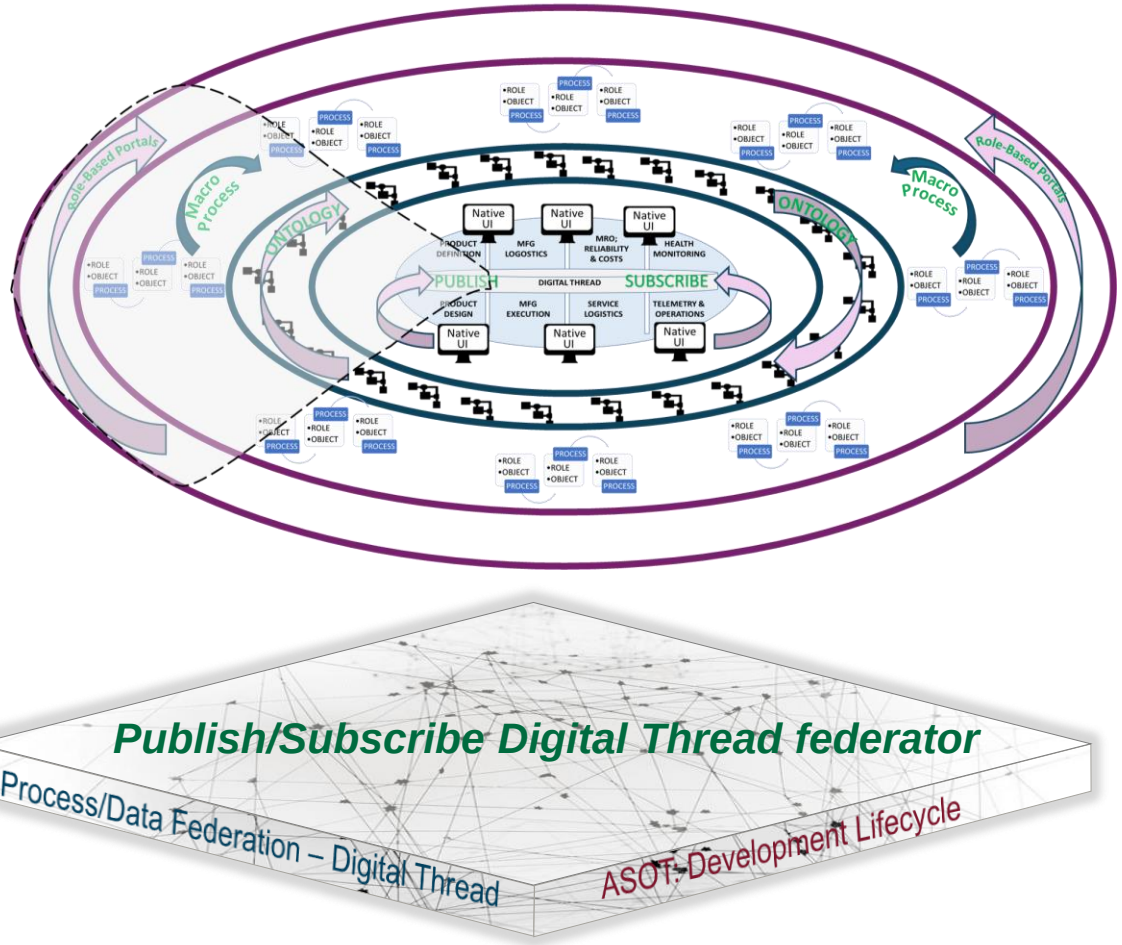
- **Model-Based Definition (MBD)**
  - PLM data associativity to system models retained
  - MBD annotations fed from RME
- **eBOM ⇔ mBOM created and maintained within PLM**
  - All BOMs maintained within PLM = “xBOM”
  - Full associativity maintained across all BOMs
- **mBOM ⇔ Process Plans ⇔ Work Instructions authored & maintained in PLM to maintain full xBOM associativity**
  - Released to production via dynamic, bi-directional link
- **Production releases are consistent to minimize cultural impact**
- **As-Planned mBOM maintained in PLM, As-Built unit serialized mBOM maintained in ERP, traceable to As-Planned mBOM to maintain persisted associative link to xBOM in PLM**



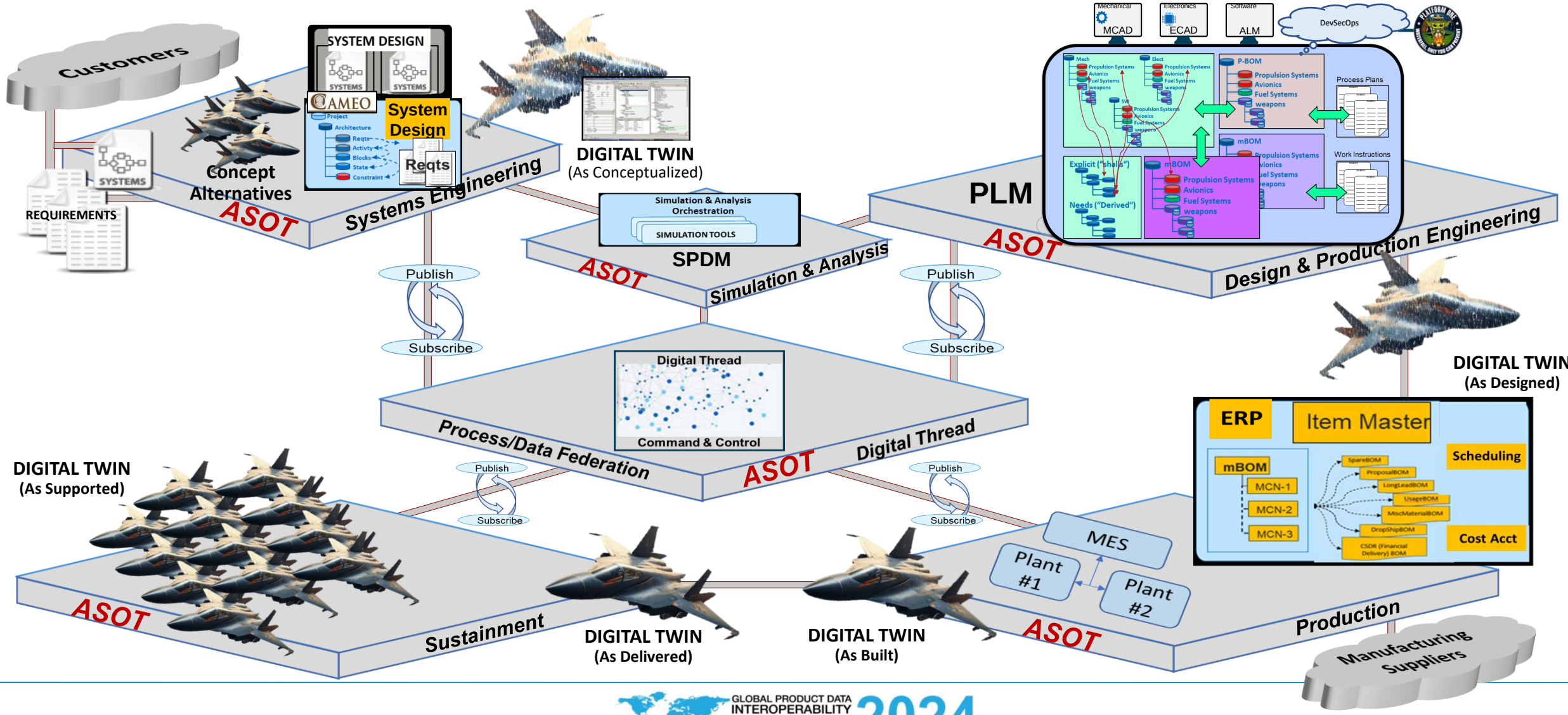
The Digital Thread Enabled Enterprise

- **Integrated digital ecosystems can bring chaotic information and change overload if not actively managed**
- **Digital Thread Must:**
  - **Provide the mechanism and management of all individual linkages and persist transactions across the ecosystem**
  - **Enable author/consumer interactions**
  - **Be capable of both trace and transmission**
  - **Initiate/manage automated workflows**
  - **Support incremental and asynchronous Release/Baseline processes**
  - **Provide the visualization and traceability controls to support cross-ASoT impact analysis, cross-domain collaboration, and lifecycle history**

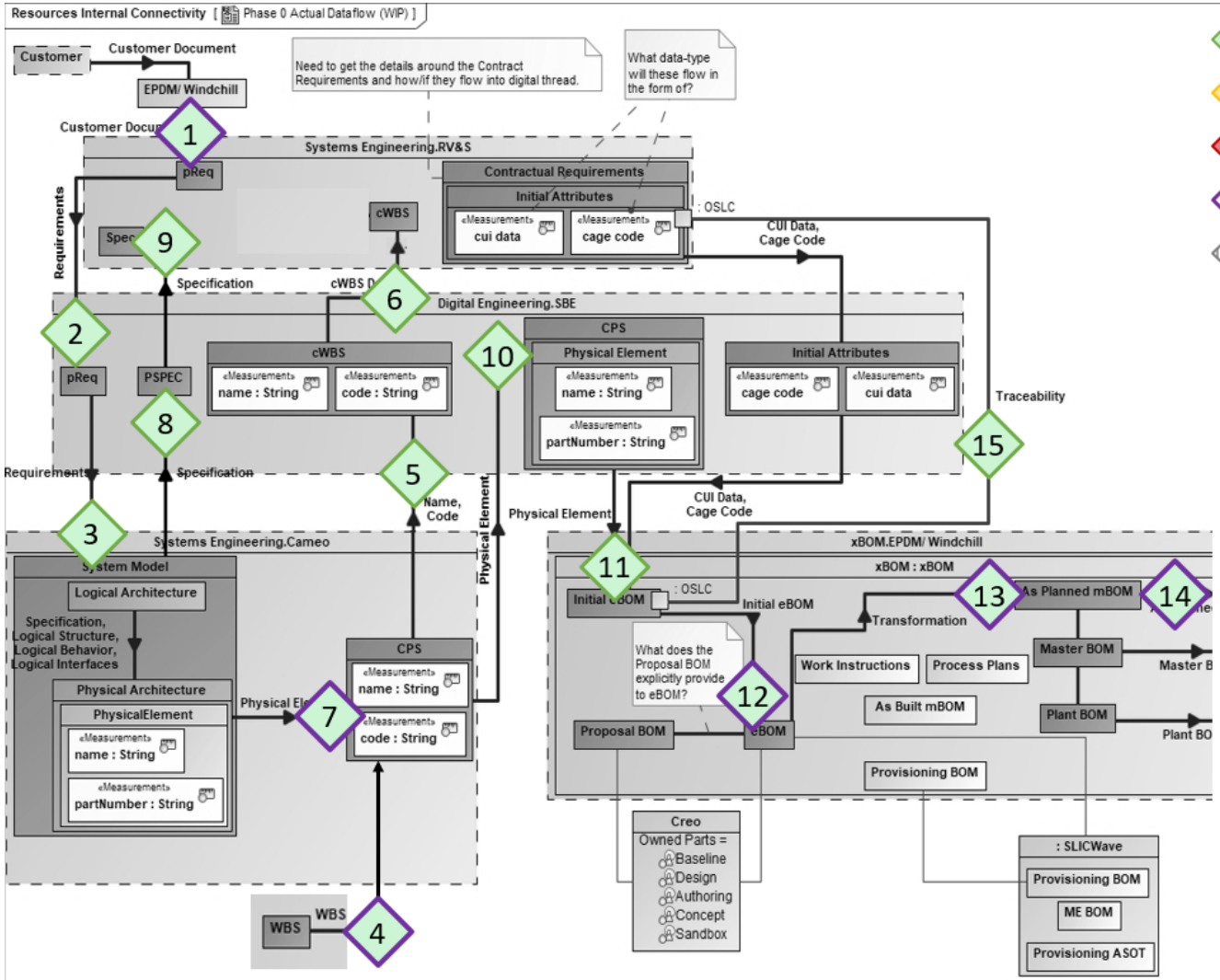
Leveraging Digital Thread with Command/Control and user Portals



Implementation……



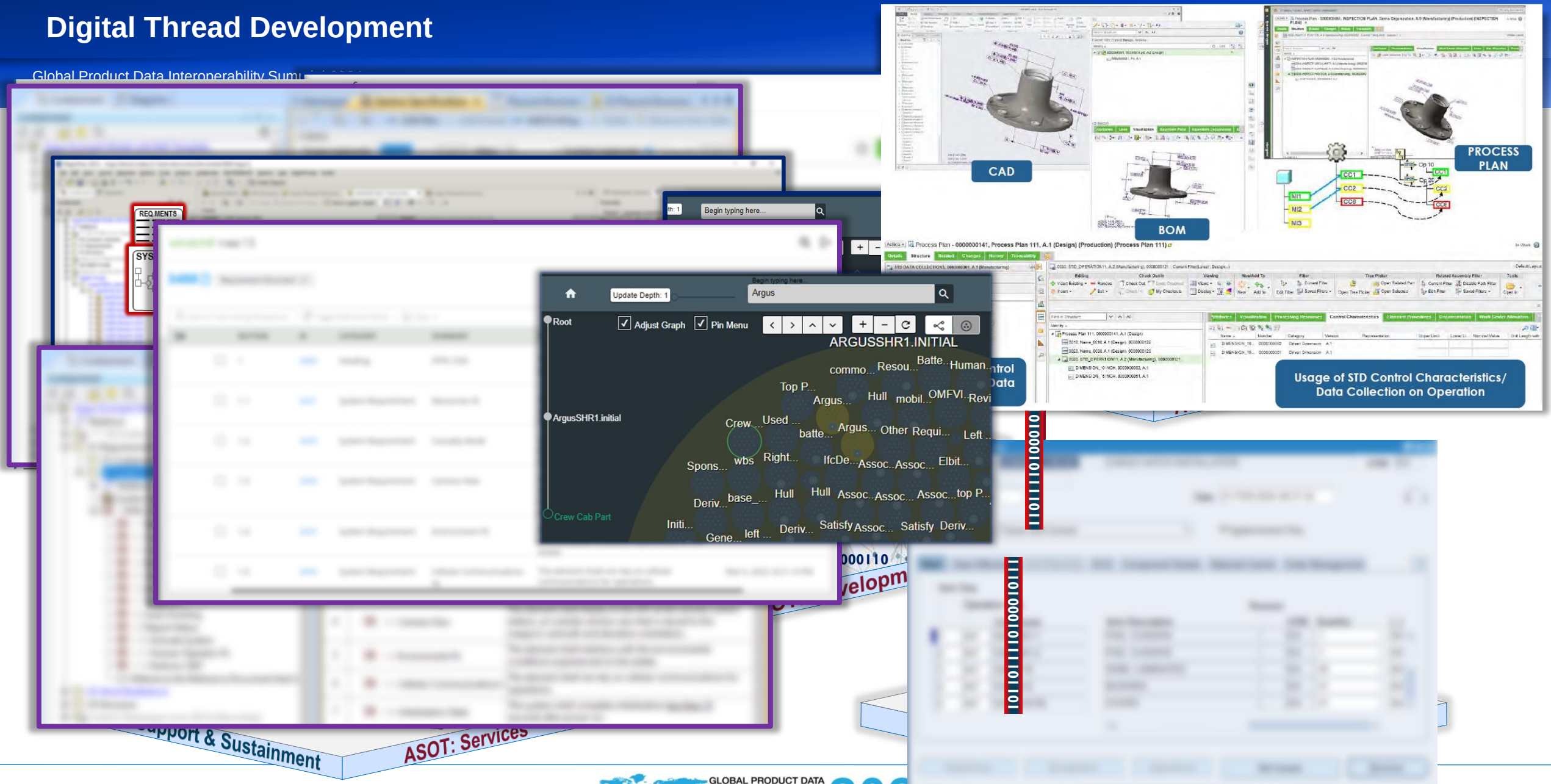
BAE Systems DT Pilot



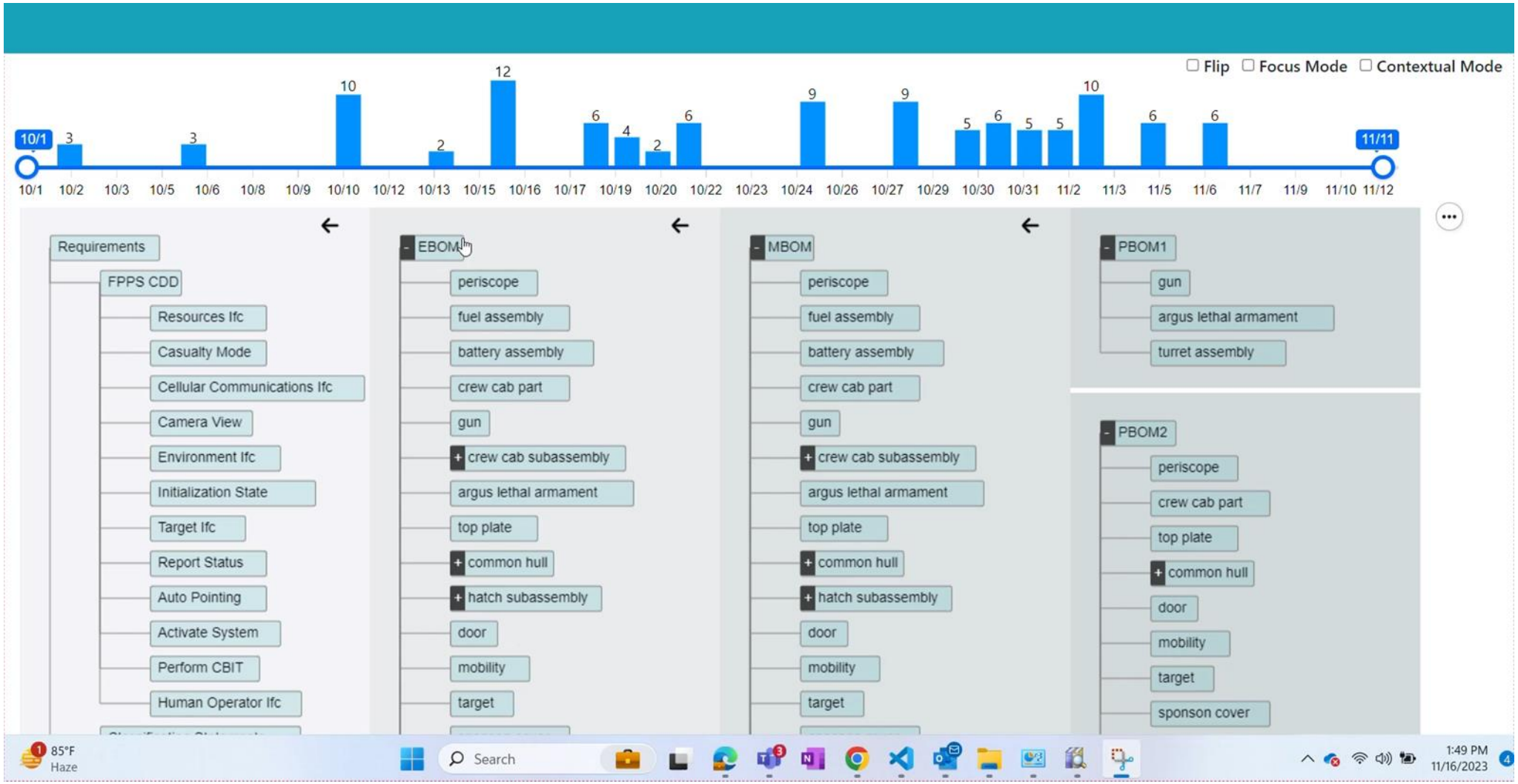
- Successful task initiated via the DT Menu UI
- Successful task, but using alternative tool(s)
- Unsuccessful task due to missing configuration
- Manual task, or requires human in the loop
- "Working", but requires more configuration

1. Reqts shredded and imported into RME
2. Customer Reqts published from RME to DT using DT native UI
3. Customer Inputs pulled from DT into MBSE as PReq using DT native UI
4. MBSE WBS template used to populate CPS
5. CPS published from MBSE using DT UI
6. Contract WBS pulled from DT into RME CWBS
7. CPS derived in MBSE from PReq + WBS data
8. Performance Specs published to DT from MBSE
9. Performance Specs pulled from DT into RME, including trace links back to Customer Inputs
10. CPS published from MBSE into DT
11. CPS pulled from DT into PLM as initial eBOM structure
12. Derive rest of eBOM from initial eBOM
13. Transform eBOM into the as-planned mBOM
14. mBOM published to DT from PLM
15. OSLC tracing between Requirements and Parts

Digital Thread Development



System Baseline Maturation through the Digital Thread



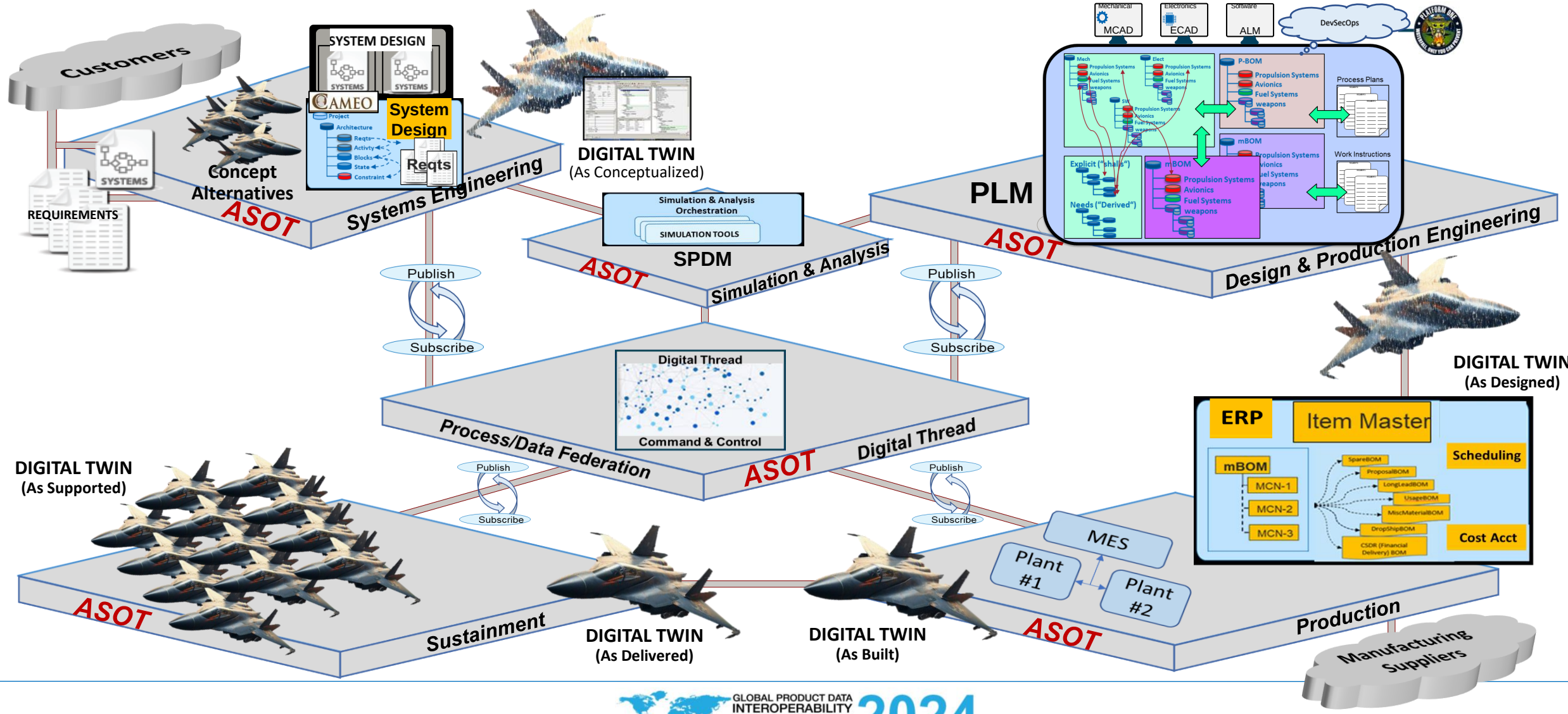
BAE Systems Digital Thread – Findings

- **The concept**
  - **The DT captures the integrated data, tool stacks, and process flows of a developing system over its lifecycle within the Digital Engineering/Enterprise ecosystem**
  - **It must also have the ability to capture and persist time-stamped releases and baselines of the system**
  - ***Drastically increases our situational awareness across the lifecycle and enables efficient and comprehensive change impact assessment and from engineering through to production and sustainment prior to implementing any changes***

- **The mechanism**
  - **The physical DT consists of reconfiguration of our data architectures, processes, and systems to establish and persist associativity within domain-specific tools (e.g. MBSE, xBOM), combined with a federated integration infrastructure to bridge domain-specific tools**

- **Key considerations**
  - **Although our MBDT implementation aims to integrate and automate as much of our development and support process as possible, not all processes will be fully automated based on current tool capabilities**
  - ➢ ***The key to the MBDT is the automated control, management, traceability, and persistence of workflows, data, and configuration baselines to enable the transformational efficiency and quality improvements that DE offers***

Q & A……


Customers
SYSTEM DESIGN
SYSTEMS
SYSTEMS
CAMEO
System Design
Reqts
SYSTEMS
REQUIREMENTS
Concept Alternatives
ASOT
Systems Engineering
DIGITAL TWIN
(As Conceptualized)
Simulation & Analysis Orchestration
SIMULATION TOOLS
SPDM
ASOT
Simulation & Analysis
Publish
Subscribe
Digital Thread
Command & Control
Process/Data Federation
ASOT
Digital Thread
Publish
Subscribe
Publish
Subscribe
Mechanical
MCAD
Electronics
ECAD
Software
ALM
DevSecOps
PLM
ASOT
Design & Production Engineering
P-BOM
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MCN-2
MCN-3
Cost Acct
DIGITAL TWIN
(As Supported)
ASOT
Sustainment
DIGITAL TWIN
(As Delivered)
DIGITAL TWIN
(As Built)
MES
Plant #1
Plant #2
ASOT
Production
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Thank You…..

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